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MacDougall et al.

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(54) **Z-AXIS DETERMINATION IN A 2D GESTURE SYSTEM**

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G06F 3/01	(2006.01)
G06K 9/46	(2006.01)

(52) **U.S. Cl.**

CPC ***G06K 9/00355*** (2013.01); ***G06F 3/017*** (2013.01); ***G06K 9/4647*** (2013.01)

(58) **Field of Classification Search**

CPC .. G06K 9/00355; G06K 9/4647; G06F 3/017; G06F 3/0481; G06F 3/04812; G06T 2207/30196; G06T 7/0042

USPC 382/106

See application file for complete search history.

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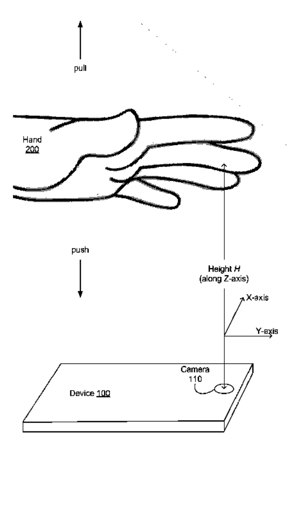
(57) **ABSTRACT**

Systems, apparatus and methods for determining a gesture are presented. According to some aspects, disclosed are systems, apparatus and methods for determining a gesture that compares different images and deduces a direction and/or distance based on a relative size change of a palm in the different images. After a reference palm size is registered, subsequent palm sizes are compared to the reference to determine if and/or how much the hand is moving. The hand gesture is determined based on these relative changes in hand movement.

23 Claims, 9 Drawing Sheets



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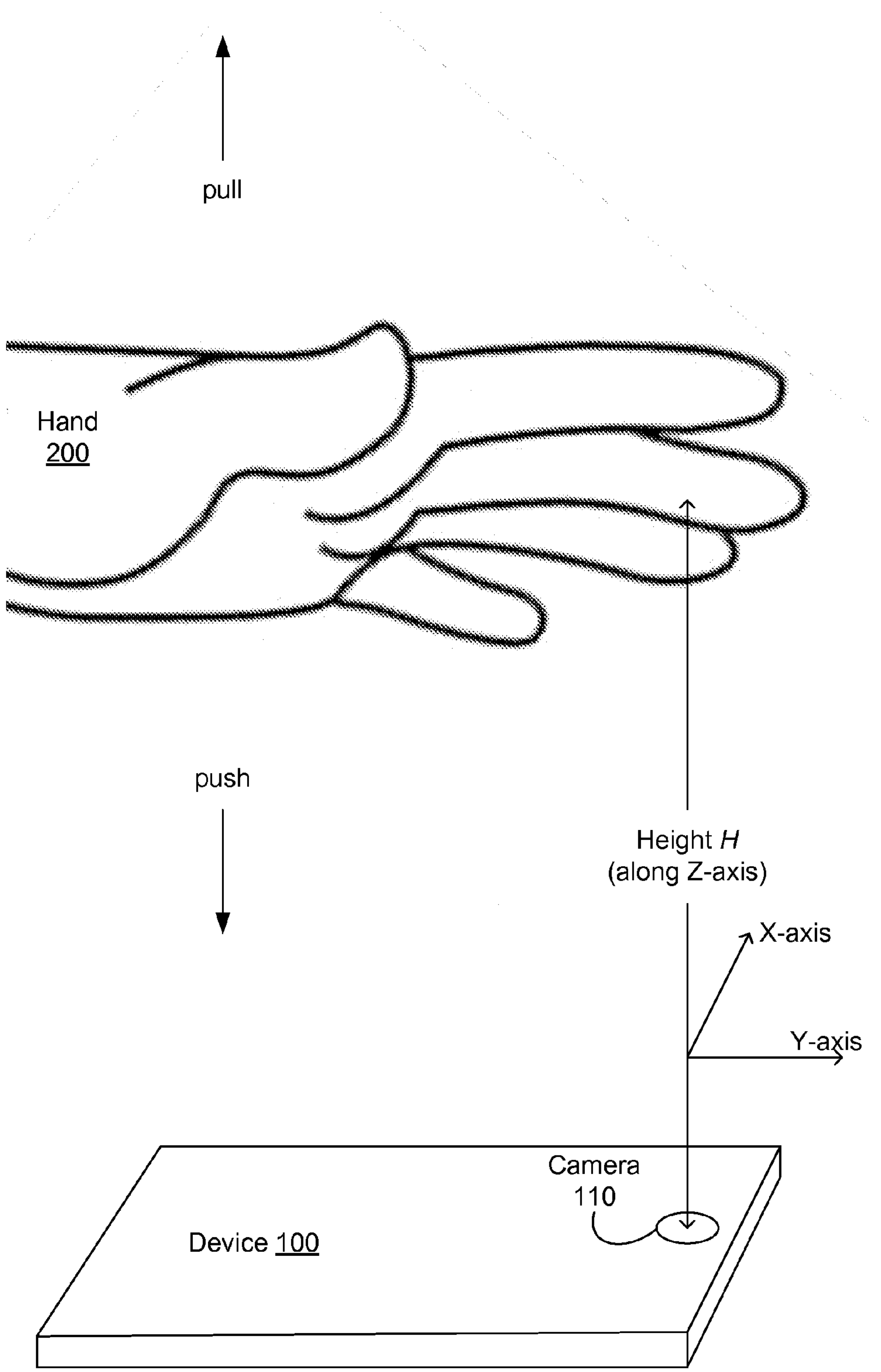
pull
Hand
200
push
Height H
(along Z-axis)
X-axis
Y-axis
Camera
110
Device 100

FIG. 1

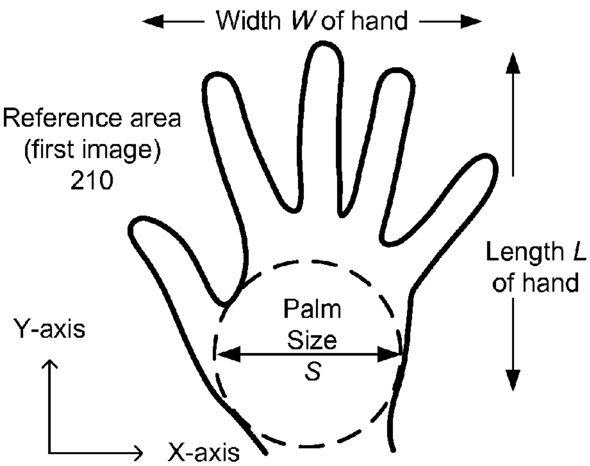

FIG. 2

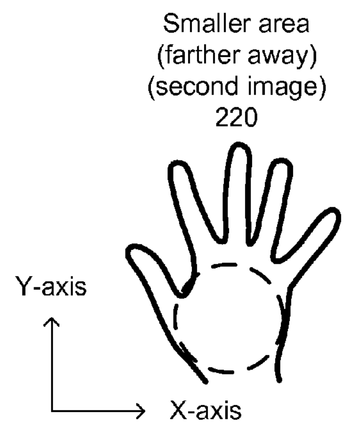

FIG. 3

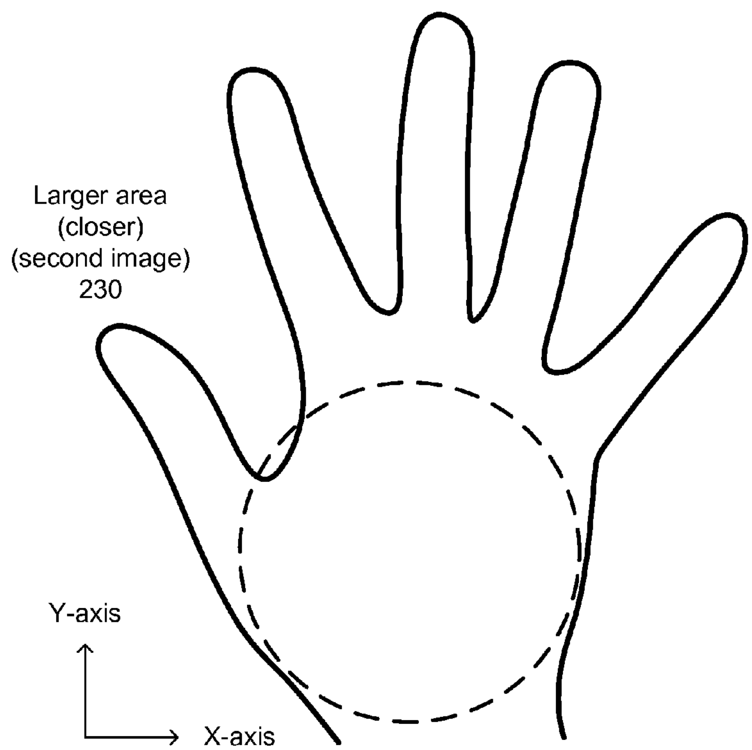

FIG. 4

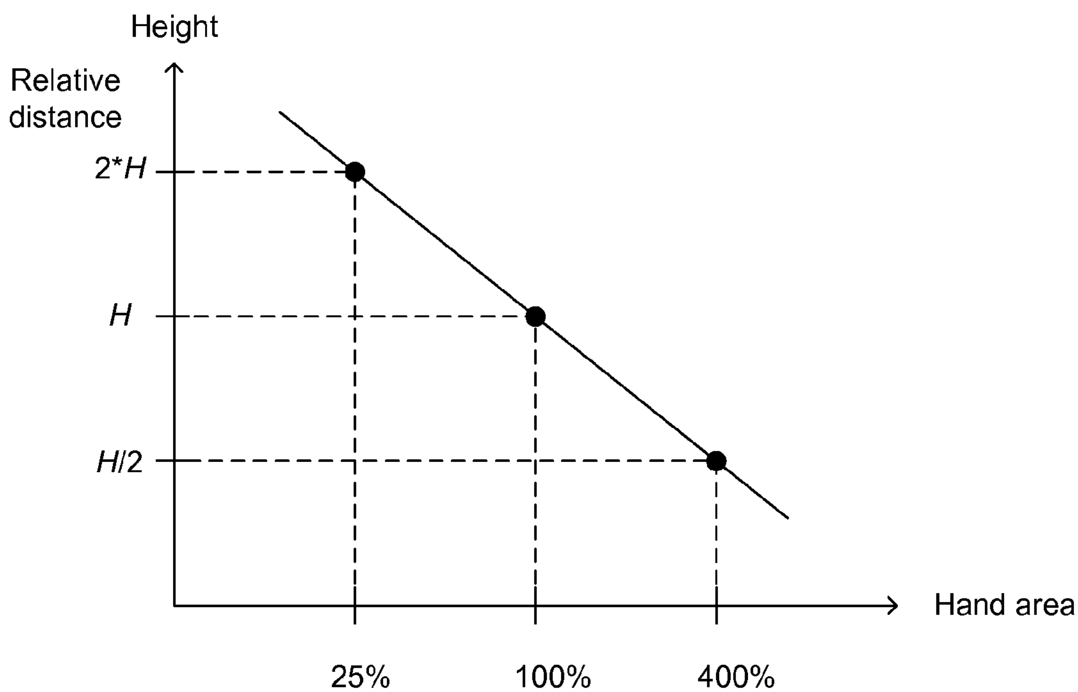

FIG. 5

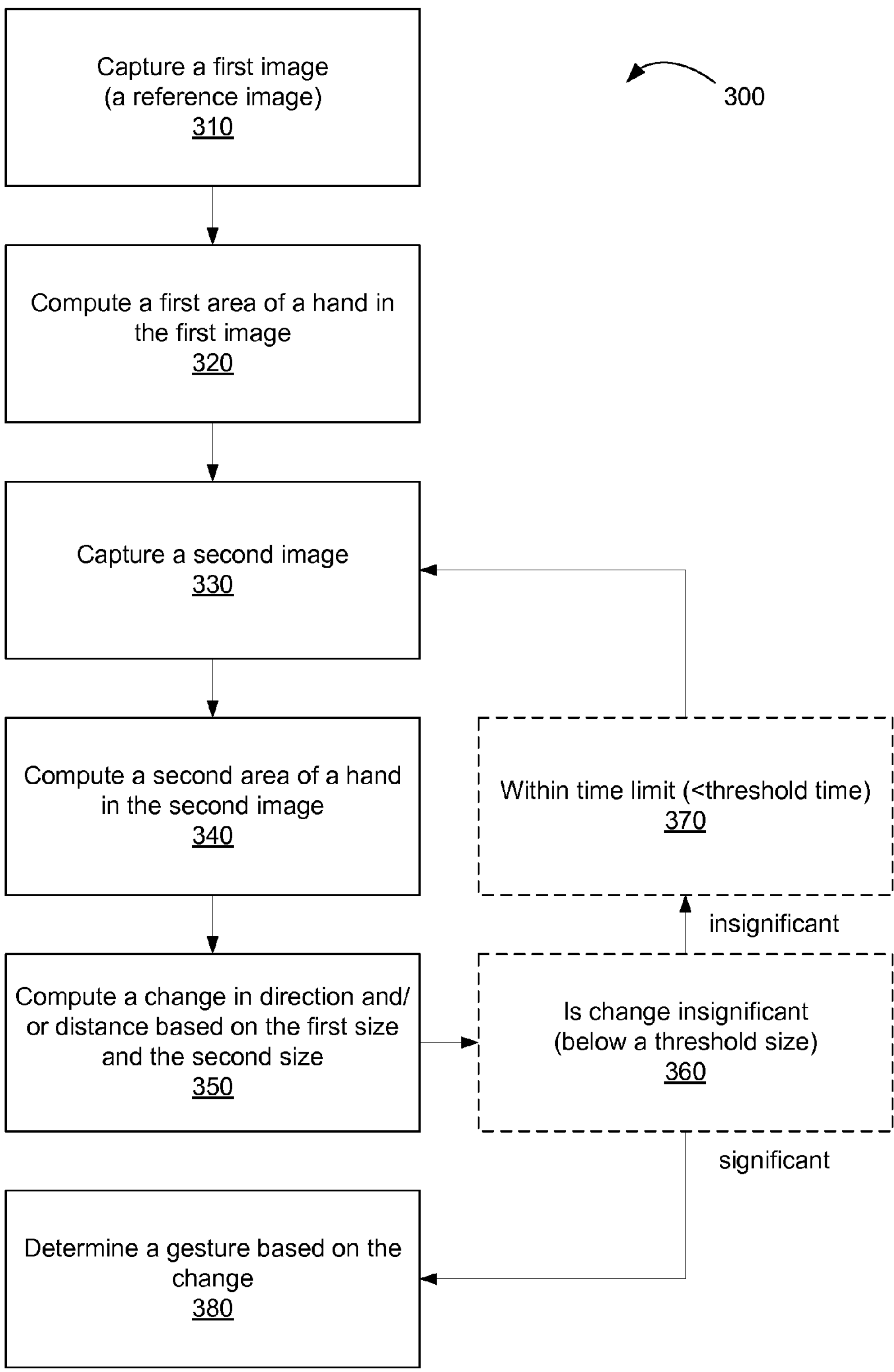
300
Capture a first image (a reference image) 310
Compute a first area of a hand in the first image 320
Capture a second image 330
Compute a second area of a hand in the second image 340
Compute a change in direction and/ or distance based on the first size and the second size 350
Is change insignificant (below a threshold size) 360
Within time limit (<threshold time) 370
insignificant
significant
Determine a gesture based on the change 380

FIG. 6

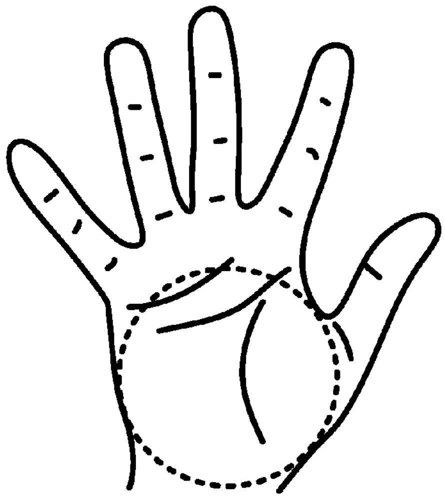

FIG. 7A

FIG. 7B

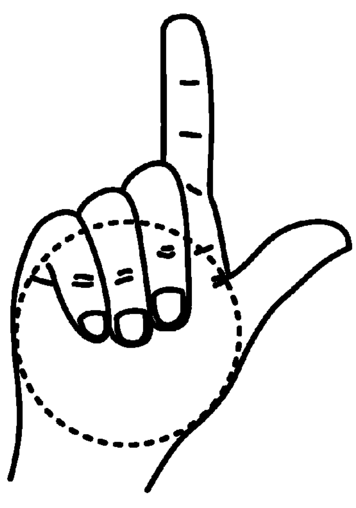

FIG. 7C

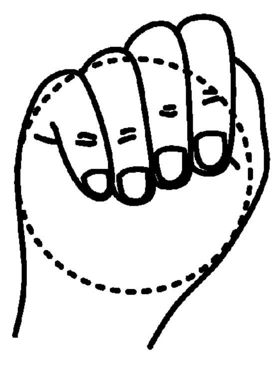

FIG. 7D

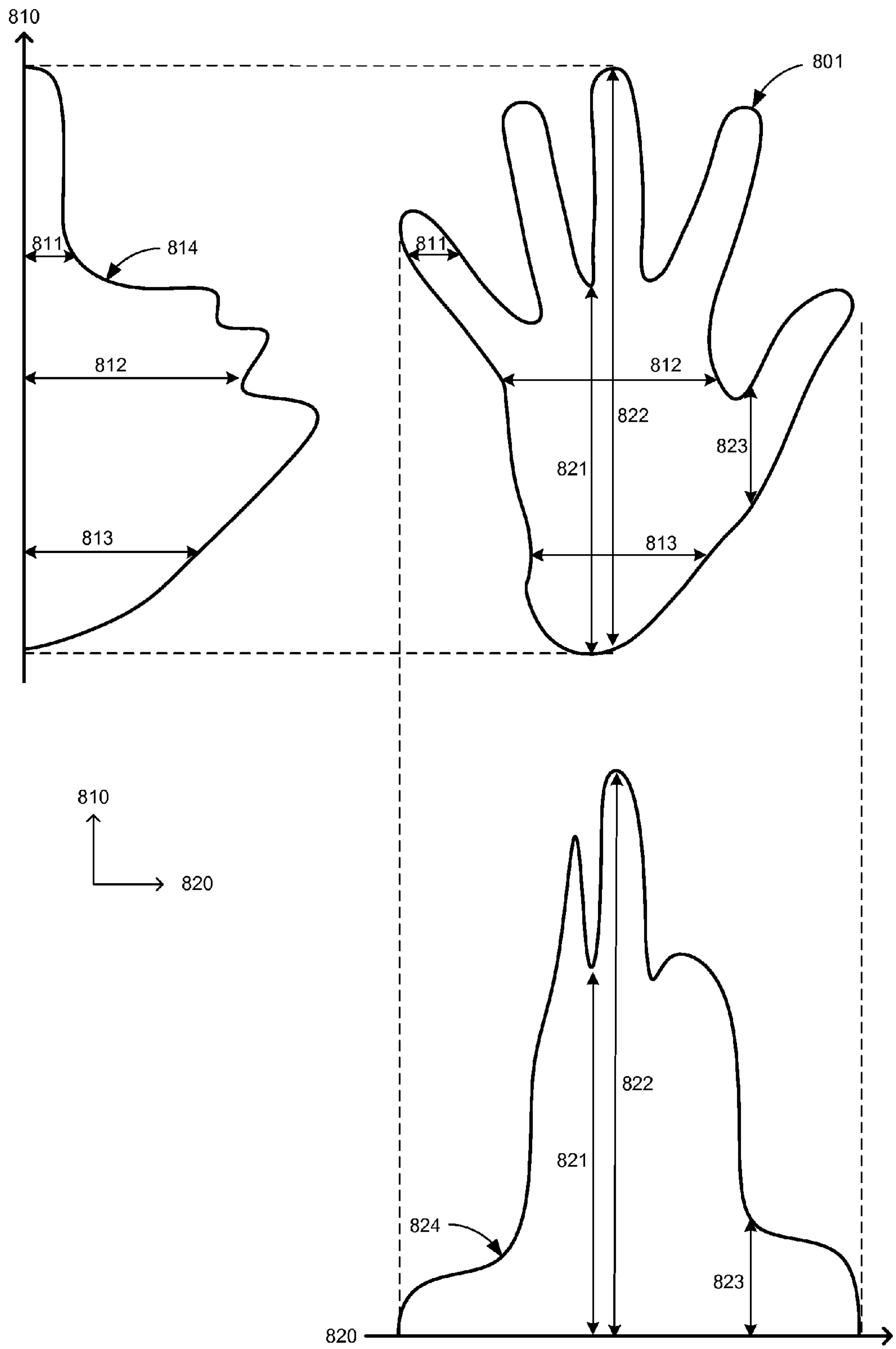
810
811
814
812
813
801
811
812
822
821
823
813
810
820
824
821
822
823
820

FIG. 8

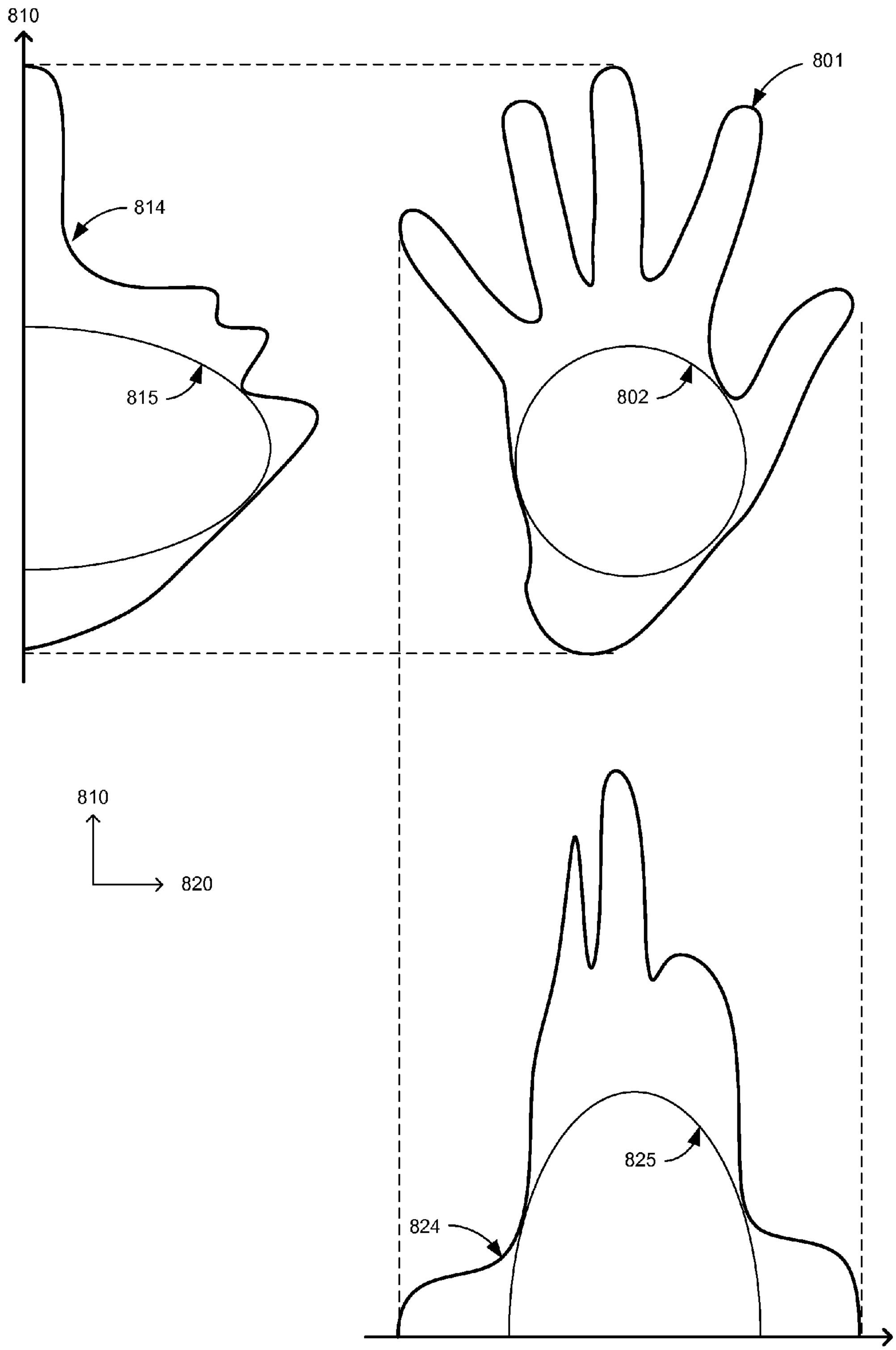

FIG. 9

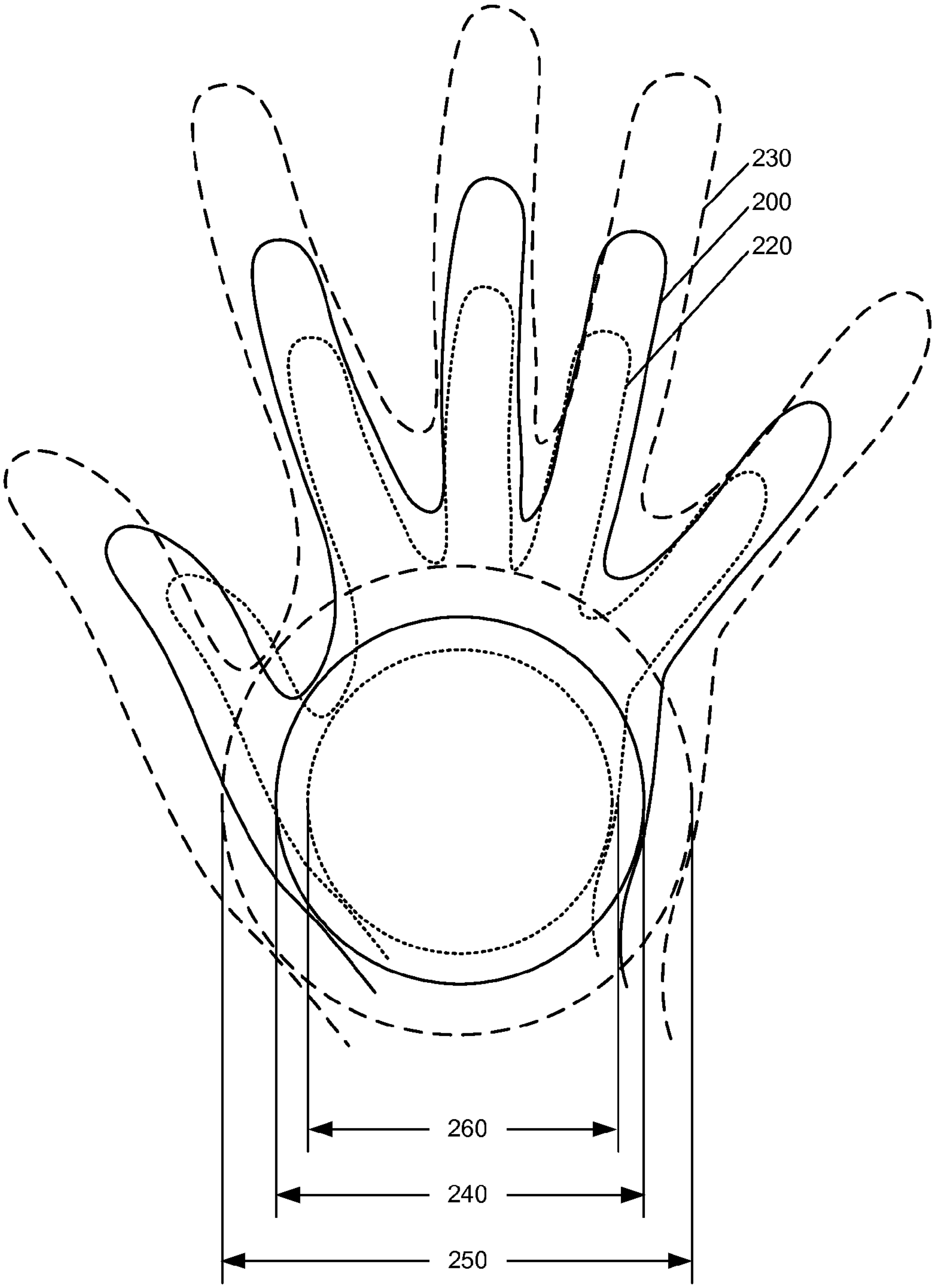

FIG. 10

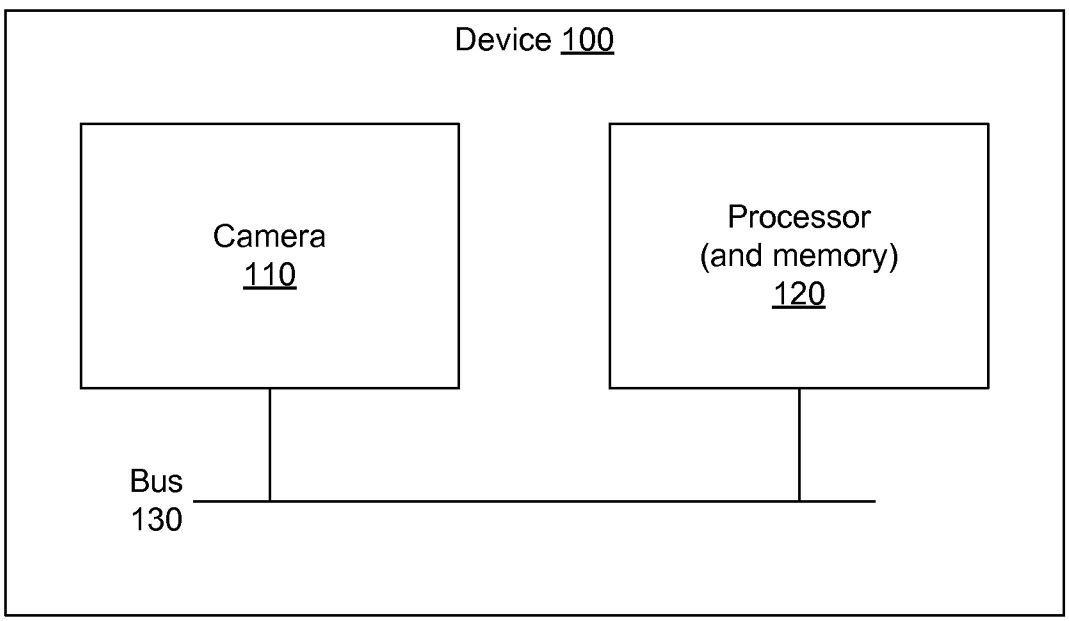

FIG. 11

Z-AXIS DETERMINATION IN A 2D GESTURE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and priority under 35 U.S.C. §119(e) to U.S. Provisional Application No. 61/891,841, filed Oct. 16, 2013, and entitled "Z-axis determination in a 2D gesture system," which is incorporated herein by reference in its entirety.

BACKGROUND

I. Field of the Invention

This disclosure relates generally to systems, apparatus and methods for determining a direction, and more particularly to determining a direction, change in distance and/or distance from a camera to a hand making gestures.

II. Background

Many mobile devices today contain a camera to capture images, for example, containing a hand. A standard two-dimensional (2D) camera image provides accurate measurements perpendicular to the camera (referred to here as a plane parallel to the x-axis and y-axis of the camera) but unfortunately little or no information about a perpendicular distance (along the z-axis of the camera) from the camera to the hand. A depth sensor or stereo cameras may provide distance information, thus supplementing a single camera. Other methods estimate an absolute perpendicular distance, usually based upon anatomical models of the hand, but are sensitive to variations in hands between different people, are sensitive to differences in poses and/or require a predefined pose to operate. What is needed is a means to determine a gesture involving a perpendicular distance to a hand using a standard 2D camera image, independently of assumption of a user's hand size and independently of hand pose.

BRIEF SUMMARY

Disclosed are systems, apparatus and methods for determining a gesture. According to some aspects, disclosed is a method for determining a gesture that compares different images and deduces a direction and/or distance based on a relative hand size. After a reference hand size is registered, subsequent hand sizes are compared to the reference to determine if and/or how much the hand is moving. The hand gesture is determined based on changes in the moving hand.

According to some aspects, disclosed is a method in a mobile device for determining a gesture, the method comprising: capturing a first image containing a hand having a first size; computing a first indication of the first size of the hand in the first image; capturing a second image containing the hand having a second size; computing a second indication of the second size of the hand in the second image; computing a relative change between the first image and the second image; and determining the gesture based on the relative change.

According to some aspects, disclosed is a mobile device for determining a gesture, the mobile device comprising: a camera configured to: capture a first image containing a hand having a first size; and capture a second image containing the hand having a second size; and a processor coupled to the camera and comprising code to: compute a first indication of the first size of the hand in the first image; compute a second indication of the second size of the hand in the second image; compute a relative change between the first image and the second image; and determine the gesture based on the relative change.

According to some aspects, disclosed is a mobile device for determining a gesture, the mobile device comprising: means for capturing a first image containing a hand having a first size; means for computing a first indication of the first size of the hand in the first image; means for capturing a second image containing the hand having a second size; means for computing a second indication of the second size of the hand in the second image; means for computing a relative change between the first image and the second image; and means for determining the gesture based on computing the relative change.

According to some aspects, disclosed is a non-transient computer-readable storage medium including program code stored thereon, comprising program code to: capture a first image containing a hand having a first size; compute the first indication of the first size of the hand in the first image; capture a second image containing the hand having a second size; compute the second indication of the second size of the hand in the second image; compute a relative change between the first image and the second image; and determine the gesture based on computing the relative change.

It is understood that other aspects will become readily apparent to those skilled in the art from the following detailed description, wherein it is shown and described various aspects by way of illustration. The drawings and detailed description are to be regarded as illustrative in nature and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWING

Embodiments of the invention will be described, by way of example only, with reference to the drawings.

FIG. **1** shows a mobile device with a nearby gesturing hand.

FIGS. **2-4** illustrate a change in hand size, in accordance with some embodiments.

FIG. **5** plots a hand size verses a distance, in accordance with some embodiments.

FIG. **6** shows a method, in accordance with some embodiments.

FIGS. **7**A-**7**D illustrate a set of hand contours of common hand poses, and the largest circle that fit within each hand contour, in accordance with some embodiments.

FIGS. **8** and **9** illustrate a method of computing an approximation of the largest circle that hits within a hand contour, in accordance with some embodiments.

FIG. **10** shows two thresholds of a hand, in accordance with some embodiments.

FIG. **11** illustrates a device, in accordance with some embodiments.

DETAILED DESCRIPTION

The detailed description set forth below in connection with the appended drawings is intended as a description of various aspects of the present disclosure and is not intended to represent the only aspects in which the present disclosure may be practiced. Each aspect described in this disclosure is provided merely as an example or illustration of the present disclosure, and should not necessarily be construed as preferred or advantageous over other aspects. The detailed description includes specific details for the purpose of providing a thorough understanding of the present disclosure. However, it will be apparent to those skilled in the art that the present disclosure may be practiced without these specific details. In some instances, well-known structures and devices are shown in block diagram form in order to avoid obscuring the concepts of the present disclosure. Acronyms and other descriptive terminology may be used merely for convenience and clarity and are not intended to limit the scope of the disclosure.

As used herein, a device, sometimes referred to as a mobile device, a mobile station (MS) or user equipment (UE), such as a cellular phone, mobile phone or other wireless communication device, personal communication system (PCS) device, personal navigation device (PND), Personal Information Manager (PIM), Personal Digital Assistant (PDA), laptop or other suitable device without such a wireless link. The term "mobile device" is intended to include devices which communicate with a personal navigation device (PND), such as by short-range wireless, infrared, wireline connection, or other connection—regardless of whether satellite signal reception, assistance data reception, and/or position-related processing occurs at the device or at the PND. Also, "mobile device" is intended to include all devices, including wireless communication devices, computers, laptops, etc. which are capable of communication with a server, such as via the Internet, WiFi, or other network, and regardless of whether satellite signal reception, assistance data reception, and/or position-related processing occurs at the device, at a server, or at another device associated with the network. Any operable combination of the above are also considered a "mobile device."

FIG. **1** shows a mobile device **100** with a nearby gesturing hand **200**. The hand **200** may be pushing towards or pulling away from the mobile device **100** or may be performing a more complex gesture. Usually, a distance between a camera **110** in the mobile device **100** and a hand **200** is unknown without a depth sensor, such as a stereoscopic camera, time-of-flight sensor, or structured light sensor. Some embodiments described herein register a hand size defining a reference size S. The hand size may be determined in various ways. For example, in some embodiments, hand size is estimated by filling the hand with a circle and using the radius, diameter or area of that circle to represent the size of the hand. In some embodiments, hand size is estimated by filling the hand with a square and using a width or area of the square to represent the hand. Other geometric shapes, such as a rectangle or oval, or single dimensions such as hand width, may be used. Alternatively, hand size may be estimated by encompassing a hand in a geometric shape rather than encompassing a geometric shape in a hand. For example, hand size may be estimated by the smallest square that encompasses a hand. For the description below, diameter of a circle that fits within a palm is used as an approximation of hand size.

In some embodiments, hand size is estimated with a palm size S, where the palm size S is a linear dimension. In other embodiments, the hand size is estimated with a palm area A. A palm is minimally influenced by the hand pose and orientation. As a result, the palm size S and palm area A are advantageous over the hand size, hand area, hand dimensions (such as, width W and length L) because these hand measurements are highly influenced by hand pose. On the other hand, palm size and palm area are advantageously less influenced by hand pose. For example, a hand in an open pose has a hand length and hand area that includes the length of the fingers, while a hand in a closed fist pose has a hand length and hand area that excludes the length of the fingers. Therefore, the hand length and hand area changes significantly depending on whether the hand is open or closed, however, the palm size remains similar throughout a variety of hand poses. Therefore, relative palm sizes are more relavant even if a hand pose changes.

A first indication of hand size may occur or be set to a first time a hand **200** is in a distinctive pose or other reference pose. A distinctive pose or reference pose may be an engagement pose, indicating to the system impending movement of the hand is to be interpreted as a gesture. For example, a first time a hand **200** provides a silhouette of a hand **200** with four fingers and a thumb, such as with a flat hand **200** perpendicular to a camera with a palm facing directly towards or away the camera. The figure shows a palm of a flat hand **200** facing directly towards a camera **110** of a mobile device **100**. The camera **110** defines Cartesian coordinate with an x-axis and a y-axis in a plane on an image captured by the camera **110** and a z-axis perpendicular axis to the image plane.

FIGS. **2**-**4** illustrate a change in hand size, in accordance with some embodiments. In FIG. **2**, a first image contains a reference size **210** of a hand **200**. Here, the reference size **210** is defined by a palm size of hand **200** in an open hand pose. Alternatively, a palm size of a hand **200**, in a closed hand pose such as a fist or the like, may be used as defining the reference size **210**. Still alternatively, a palm size of a hand, where the hand is performing a part of a hand gesture, may define an indication of the reference size **210**. To set a reference size **210**, a user may be prompted to hold a hand position over a mobile device **100**. For example, the user may be requested to hold an open hand over the mobile device **100**. In some embodiments, a user fixes a hand **200** at a variable (unknown) height above the mobile device **100**. In such embodiments, a relative height may be determined. In other embodiments, a user fixes a hand **200** at a particular height above the mobile device **100**. For example, the user may be instructed to fix an open hand **200** at one foot above the mobile device **100**. In such embodiments, the user may be instructed to fix a hand at a particular height above the mobile device **100** that is dependent upon the field of view (FOV), range, and resolution of a particular camera and lens being used, to assure that the hand may be detected within a sufficient range of motion for a user to complete a gesture without unintentionally moving the hand outside the FOV, range, and resolution of the particular camera and lens being used.

In FIG. **3**, a second image shows the same hand **200** farther away. When the hand **200** is farther away, the camera **110** captures a second image with a smaller size **230** when compared to the reference size **210**. Before comparing the second image to the first image, the mobile device **100** may compensate for a field of view (FOV) of a particular camera and lens being used. Therefore, a hand size from the first (reference) image may be directly compared to a hand size from the second image. As such, a relative difference between lengths may be determined.

In FIG. **4**, another second image shows the same hand **200** closer to the camera **110**. When the hand **200** is closer, the camera **110** captures a second image with a larger size **220** when compared to the reference size **210**. When compared to an indication of the reference size **210**, an indication of the smaller size **230** or the larger size **220** results in a relative difference to the reference size **210**.

FIG. **5** plots a hand size verses a distance, in accordance with some embodiments. Neither relative distance nor hand size is shown on a linear scale. Similar, the processor has compensated for effects of a FOV of a particular lens. The non-linear scales show a relationship between relative distance and hand size such that a translation between the two falls on a line. If drawn on a linear scale, the graph would appear having an inverse proportional relationship. That is, relative distance is proportion to an inverse of hand size after accounting for a particular FOV of a camera **110**.

In FIG. **5**, a relative distance is shown with respect to a hand size. The value of H may be unknown. A reference size **210** is set to 100% for a height H. When an image shows the hand **200** is 50% of the reference size **210** (e.g., a smaller size **230**), the relative distance is 2*H. When an image shows the hand **200** is 200% of the reference size **210** (e.g., a larger size **220**), the relative distance is H/2. If H is referred to as a relative height, 2*H and H/2 are determinable relative heights. Therefore, an arbitrary hand size may be translated to a relative distance above the camera **110**, without calculation of the absolute height of the hand, and without knowledge of the absolute hand size or the assumption that the hand matches an anatomical model of a hand size. The graph may be used to determine a direction from a reference height H, wherein the reference height H results in an image of a hand **200** having a relative size **210**. For example, the graph may be used to determine if a hand **200** is moving towards or away from a camera **110**. In addition to direction, the graph may be used to compute a relative height with respect to the reference height H.

FIG. **6** shows a method **300**, in accordance with some embodiments. At **310**, a camera **110** captures a first image. The first image is a reference image containing a hand **200** having a reference size. At **320**, a processor in a mobile device **100** computes an indication of the first size as a reference size. As previously stated, the indication of a size may be a size S corresponding to a diameter or an area of the palm. At **330**, the camera **110** also captures a second image. Step **330** may occur before or after step **320**. At **340**, the processor computes an indication of the second size of the hand **200** within the second image. At **350**, the processor computes a change between the first image and the second image wherein the change includes a direction and/or a distance based on the first indication of size and the second indication of size. The change may be only a direction, only a relative distance, or both a direction and a relative distance. For example, if the second size is less than the first size, the hand **200** has moved away from the reference height. If the second size is greater than the first size, the hand **200** has moved towards the reference height. Alternatively, two sequential images may be examined to determine whether the hand **200** is currently moving up (away from the camera **110**) or down (towards the camera **110**).

Optionally, at **360**, a determination is made to check if a change is insignificant, for example, if the change is below a threshold size. If the change is insignificant, processing may continue at optional step **370** or again at step **330**. If the change is significant, processing may continue at step **380**.

At **370**, a time limit T may be checked to see whether one interaction occurs within a single session. For example, processing at step **330** may continue only if a threshold time (e.g., T=5 seconds) has not been exceeded. During the time limit T, the change in palm size or area may be used to identify a push or a pull. In this case, a hand **200** stays within a viewing frame and moves in height. The computed height change may result in a gesture defining zooming in or out operation. Also in this case, a hand **200** may disappear from a viewing frame by being too low or too high along the Z-axis. For example, when a hand **200** is too close it occupies a majority of an image and cannot be detected. When a hand **200** is too far it is smaller than a defined minimum number of pixels for a hand **200**. Alternatively, a hand **200** may disappear because it is outside of the X-Y plane of the camera **110**. That is, the hand **200** exits a view of a camera **110**. For example, a hand **200** may exit at a low height and then reappear at a higher height. Such a gesture includes a close interaction followed by a far interaction. At **380**, the processor determines a gesture based on the change.

FIGS. **7**A-**7**D illustrate a set of hand contours of common hand poses, and the largest circle that fit within each hand contour, in accordance with some embodiments. For many common hand poses, the largest circle within a silhouette of a hand corresponds closely to the palm, therefore a palm may be detected within a segmented contour of a hand, as the largest circle that fits within the hand contour. FIG. **7**A shows an open hand with fingers and thumb spread out. FIG. **7**B shows an open hand with fingers and thumb together. FIG. **7**C shows partially closed hand with an index finger and a thumb pointing out. FIG. **7**D shows closed hand with fingers and thumb together in a fits.

It should be apparent that the palm size remains fairly constant for these various poses, while other metrics of hand size such as hand length and hand area are more greatly affected by the hand pose.

FIGS. **8** and **9** illustrate a method of computing an approximation of the largest circle that hits within a hand contour, in accordance with some embodiments. A palm size may be used as an approximation of the hand size by using the largest circle that fits within the hand contour. This approximation requires relatively little computation as compared to determining an area of a hand.

In FIG. **8**, two axes **810** and **820** are identified. The axes may correspond to the length of the hand and the width of the hand. Alternatively, the axes may correspond to the vertical and horizontal axes of the image. The longest contagious segments (for example, **811**, **812** and **813**) perpendicular to axis **810** are projected along axis **810** to form a projected contour **814**. It can be seen in this example that segments identified as **811**, **812**, and **813** within projected contour **814** match the length of corresponding segments **811**, **812**, and **814** within hand contour **801**. Similarly, the longest contagious segments (for example **821**, **822**, **823**) perpendicular to axis **820**, are projected along axis **820** to form a projected contour **824**.

In FIG. **9**, within projected contour **814**, the largest half-ellipse **815** is found Similarly, within projected contour **824**, the largest half-ellipse **825** is found. Half-ellipses **815** and **825** may be back-projected into hand contour **801** to identify circle **802**. Circle **802** is an approximation of the largest circle within the hand contour. Other shapes may be used instead of half-ellipses. For example, a half-circle, square or rectangle may be used.

In an alternative embodiment of a method of identifying a palm, the palm position is identified as the point furthest from any point on a hand and the palm radius is identified as the distance of that point to the closest point on the contour. This method may be computed as a series of morphology erosion operations computed on a segmentation of a hand, applied recursively until any further erosion results in a null image. The number of recursions equates to the radius of the palm and the remaining points represent the center of the palm.

FIG. **10** shows two thresholds of a hand **200**, in accordance with some embodiments. A palm size **240** of a hand **200** is shown with a solid line. A threshold size increase to palm size **250**, corresponding to hand **220**, is shown. A threshold size decrease to palm size **260**, corresponding to hand **230**, is also shown. This threshold size increase or decrease may be used to determine whether a change is insignificant or significant.

FIG. **11** illustrates a mobile device **100**, in accordance with some embodiments. The mobile device **100** includes a camera **110** and a processor **120** having memory. The camera **110** is configured to capture a first image containing a hand **200** having a first size. The camera **110** also is configured to capture a second image containing the hand **200** having a second size. The processor **120** and memory are coupled to the camera, for example, via a bus **130**. The processor **120** and memory comprise code to: (1) compute a first indication of the first size of the hand in the first image; (2) compute a second indication of the second size of the hand in the second image; (3) compute a change between the first image and the second image; and (4) determine the gesture based on computing the change.

The camera **110** acts as: (1) a means for capturing a first image containing a hand having a first size; and (2) a means for capturing a second image containing the hand having a second size. The processor **120** and memory act as: (1) a means for computing a first indication of the first size of the hand in the first image; (2) a means for computing a second indication of the second size of the hand in the second image; (3) a means for computing a change between the first image and the second image; and (4) a means for determining the gesture based on computing the change.

The methodologies described herein may be implemented by various means depending upon the application. For example, these methodologies may be implemented in hardware, firmware, software, or any combination thereof. For a hardware implementation, the processing units may be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, electronic devices, other electronic units designed to perform the functions described herein, or a combination thereof.

For a firmware and/or software implementation, the methodologies may be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. Any machine-readable medium tangibly embodying instructions may be used in implementing the methodologies described herein. For example, software code may be stored in a memory and executed by a processor unit. Memory may be implemented within the processor unit or external to the processor unit. As used herein the term "memory" refers to any type of long term, short term, volatile, nonvolatile, or other memory and is not to be limited to any particular type of memory or number of memories, or type of media upon which memory is stored.

If implemented in firmware and/or software, the functions may be stored as one or more instructions or code on a computer-readable medium. Examples include computer-readable media encoded with a data structure and computer-readable media encoded with a computer program. Computer-readable media includes physical computer storage media. A storage medium may be any available medium that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to store desired program code in the form of instructions or data structures and that can be accessed by a computer; disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

In addition to storage on computer readable medium, instructions and/or data may be provided as signals on transmission media included in a communication apparatus. For example, a communication apparatus may include a transceiver having signals indicative of instructions and data. The instructions and data are configured to cause one or more processors to implement the functions outlined in the claims. That is, the communication apparatus includes transmission media with signals indicative of information to perform disclosed functions. At a first time, the transmission media included in the communication apparatus may include a first portion of the information to perform the disclosed functions, while at a second time the transmission media included in the communication apparatus may include a second portion of the information to perform the disclosed functions.

The previous description of the disclosed aspects is provided to enable any person skilled in the art to make or use the present disclosure. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects without departing from the spirit or scope of the disclosure.

What is claimed is:

1. A method in a mobile device for determining a gesture, the method comprising:
- capturing a first image containing a hand having a first size;
- filling the hand in the first image with a first circle;
- computing a first indication of the first size of the hand in the first image based on the first circle;
- capturing a second image containing the hand having a second size;
- filling the hand in the second image with a second circle;
- computing a second indication of the second size of the hand in the second image based on the second circle;
- computing a relative change between the first image and the second image; and
- determining the gesture based on the relative change.

2. The method of claim **1**, wherein the first image and the second image are received from an optical camera.

3. The method of claim **1**, wherein the first image and the second image are received from an infrared camera.

4. The method of claim **1**, wherein the first image and the second image are received from an ultrasonic camera.

5. The method of claim **1**, wherein the hand in the first image and the second image comprises an open palm.

6. The method of claim **1**, further comprising:
- detecting the hand in the first image; and
- registering the first indication of the size as a reference hand size.

7. The method of claim **1**, wherein the relative change indicates a direction and distance.

8. The method of claim **7**, wherein computing the relative change results in a relative distance.

9. The method of claim **1**, further comprising repeating acts of:
- re-capturing a next image containing the hand;
- re-computing an indication of the next size of the hand in the next image; and
- re-computing the relative change.

10. The method of claim **9**, further comprising determining the relative change is less than a threshold.

11. The method of claim **9**, further comprising determining a time, between capturing the first image and capturing the second image, is less than a threshold time.

12. The method of claim **1**, further comprising determining difference between the first indication of size and the second indication of size is greater than a threshold.

13. The method of claim **1**, further comprising interpreting the gesture.

14. A mobile device for determining a gesture, the mobile device comprising:

a camera configured to:

capture a first image containing a hand having a first size; and

capture a second image containing the hand having a second size; and

a processor coupled to the camera and comprising code to:

fill the hand in the first image with a first circle;

compute a first indication of the first size of the hand in the first image based on the first circle;

fill the hand in the second image with a second circle;

compute a second indication of the second size of the hand in the second image based on the second circle;

compute a relative change between the first image and the second image; and

determine the gesture based on the relative change.

15. The mobile device of claim **14**, wherein the camera comprises an optical camera.

16. The mobile device of claim **14**, wherein the camera comprises an infrared camera.

17. The mobile device of claim **14**, wherein the camera comprises an ultrasonic camera.

18. The mobile device of claim **14**, wherein the code to compute the relative change results in a relative distance.

19. A mobile device for determining a gesture, the mobile device comprising:

means for capturing a first image containing a hand having a first size;

means for filling the hand in the first image with a first circle;

means for computing a first indication of the first size of the hand in the first image based on the first circle;

means for capturing a second image containing the hand having a second size;

means for filling the hand in the second image with a second circle;

means for computing a second indication of the second size of the hand in the second image based on the second circle;

means for computing a relative change between the first image and the second image; and

means for determining the gesture based on computing the relative change.

20. The mobile device of claim **19**, wherein the relative change indicates a direction and distance.

21. The mobile device of claim **20**, wherein computing the relative change results in a relative distance.

22. The mobile device of claim **19**, further comprising means for interpreting the gesture.

23. A non-transient computer-readable storage medium including program code stored thereon, comprising program code to:

capture a first image containing a hand having a first size;

fill the hand in the first image with a first circle;

compute the first indication of the first size of the hand in the first image based on the first circle;

capture a second image containing the hand having a second size;

fill the hand in the second image with a second circle;

compute the second indication of the second size of the hand in the second image based on the second circle;

compute a relative change between the first image and the second image; and

determine the gesture based on computing the relative change.

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